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ENVIRONMENTAL

Mitch Cron
Remedial Project Manager
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Subject
Evaluation of 1,4-Dioxane Treatment for the Bally Drinking Water Supply System, Bally Groundwater Contamination Site, Bally, Pennsylvania

Date
20 August 2003

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Our ref
NP000568.0002

Dear Mr. Cron:

On behalf of American Household, Inc. (AHI), ARCADIS presents this update and evaluation of ex-situ treatment for 1,4-dioxane present in the Borough of Bally Public Water Supply (PWS) in the Borough of Bally, Berks County, Pennsylvania. Treatment of 1,4-dioxane in the groundwater from the present drinking water supply well for the Bally PWS (Municipal Well No. 3) is an option that is being considered along with other options, such as developing an alternate drinking water source that is of adequate capacity and satisfactory water quality. This update and evaluation focuses on the feasibility of treatment to low levels such as the 3 or 6 micrograms per liter (μg/L) for 1,4-dioxane proposed by the United States Environmental Protection Agency (USEPA) and Pennsylvania Department of Environmental Protection (PADEP) for the Bally PWS.

Background

Based on a comprehensive review of available treatment technologies, the best available technologies (BAT) for treatment of 1,4-dioxane for a PWS (such as the Bally system) are most likely **gaseous ozone (ozonation)** and **ultra-violet light/hydrogen peroxide (UV/peroxide)** treatment. Other treatment technologies and variations of advanced oxidation processes (AOPs) exist, but are less attractive for a variety of reasons, not the least of which is the lack of performance history and data for applications comparable to the Bally PWS.

Treatment Technology Testing and Vendor/Operator Survey

ARCADIS performed bench-scale testing of the ozonation and UV/peroxide technologies on water samples collected from Bally Municipal Well No. 3. These water samples were collected in March, April and June 2003, from a collection point located after the second air stripping tower but prior to the water chlorination system. The ozonation testing was performed by Michigan State University, and the UV/peroxide testing was performed by Trojan Technologies, Inc. Results of pre- and post-treatment 1,4-dioxane concentrations, as well as reaction byproduct data, are presented on the attached Tables 1 through 4.

The bench scale test results included the following:

- The ozonation process reduced the 1,4-dioxane from 60 µg/L to less than 1 µg/L after 15 minutes of contact time with a 5% ozone feed into one liter of water;
- The UV/peroxide process reduced the 1,4-dioxane concentrations from approximately 290 µg/L (sample spiked with additional 1,4-dioxane) to less than 30 µg/L after 120 minutes of contact time using a 30 watt UV lamp[1];
- The ozonation process left **a** by-product residual of 13 µg/L **of formaldehy**de and 60 µg/L **of bromate after** 15 minutes contact time;
- The UV/peroxide process left a by-product residual of 42 µg/L of formaldehyde and no bromate (non-spiked sample).

formaldehyde
bromate

ARCADIS also surveyed multiple vendors, operators and regulators of systems presently used for 1,4-dioxane treatment as part of this evaluation. This survey allowed an assessment of other parties' experiences for treatment of 1,4-dioxane.

While other ozonation and UV/peroxide treatment systems that treat 1,4-dioxane are in operation, there is a limited body of data on their effectiveness, performance and practicability. This limited data does not allow for confident extrapolation of performance results to a system such as the Bally PWS. For the fourteen treatment system regulators, vendors and operators that were identified and contacted, only one instance was found where an operating treatment system discharges water directly to a PWS. However, 1,4-dioxane is not the primary contaminant of concern at this site. The influent 1,4-dioxane concentrations for that treatment system typically are less than 3 µg/L, which is far below the levels at the Bally Municipal Well No. 3.

For this same group of vendors and operators, systems with similar or higher concentrations of 1,4-dioxane as Municipal Well No. 3 did not discharge directly to a potable water system, and/or were configured in a way that would be impractical for the Bally PWS. **As such, a history of consistent treatment to 3 µg/L or less for influent 1,4-dioxane concentrations and flow rates similar to those observed at Municipal Well No. 3, for a system similar to the Bally PWS, was not discovered during ARCADIS' survey.**

Relevant Concerns for Potential Bally PWS Treatment System

There are several key concerns, related to the treatment of 1,4-dioxane-impacted groundwater for the Bally system, which must be considered.

[1] UV/peroxide samples were spiked for this test to ensure that the pre- and post-treatment 1,4-dioxane concentrations were well above Trojan's analytical detection limit of 10 µg/L. Spiking has no effect on the actual treatment assessment, as reaction rates are linear, and the kinetic rate at these relative concentrations is comparable (i.e. spiked compared to non-spiked samples).

The most important is the ability of any treatment system to reliably and consistently treat 30 to 60 µg/L of 1,4-dioxane to less than 3 µg/L, and the formation and control of reaction byproducts. The vendor/user survey and bench scale testing recently conducted do not adequately demonstrate the ability of UV/peroxide or ozonation (BAT for 1,4-dioxane) to consistently achieve levels of 1,4-dioxane below 3 µg/L. As noted in this letter, there is a lack of analogous field data and questions about the accuracy of the extrapolation of the lab data to the field in this situation.

However, maybe most importantly, reaction byproducts residuals, such as bromate and formaldehyde, can form during treatment by these technologies. Avoidance of byproduct formation would need to be guaranteed for any treatment system for Municipal Well No. 3 if this well would be used for the Bally PWS.

As indicated in the attached tables, bromate was detected in water treated by ozonation at concentrations of approximately 50 to 60 µg/L, well above the USEPA and PADEP Drinking Water MCL of 10 µg/L. A sample of UV/peroxide-treated water was also analyzed for formaldehyde as part of the bench-scale testing. Formaldehyde was detected in UV/peroxide-treated water at a concentration of 42 µg/L. Although no MCL exists for formaldehyde, similar to 1,4-dioxane, EPA has identified health concerns associated with the consumption of drinking water containing formaldehyde. For the treatment system vendors and operators contacted by ARCADIS, consistent byproducts testing for compounds such as bromate and formaldehyde generally is not conducted. As such, a definitive history of systems with a documented absence of treatment byproducts, that would be sufficient to allow extrapolation to Municipal Well No. 3 water and the Bally PWS, was not clearly evident based on ARCADIS' survey.

Development of Drinking Water Standards & BACT

As EPA is aware, the Safe Drinking Water Act ("SDWA") empowered EPA to define drinking water standards. However, EPA is required by law (1996 Amendments to the SDWA) to establish those standards through a process that involves determining whether setting a standard is appropriate and, if so, what that standard should be. Scientific and technological issues are considered including factors ranging from occurrence in the environment to health effects. The EPA must go through three steps in standard setting: 1) identify drinking water quality problems; 2) prioritize the problems; and, 3) propose and finalize a drinking water regulation. **The EPA then sets a maximum contaminant level goal (MCLG), which is typically set above zero for carcinogens for which a safe dose can be determined.** After the MCLG is set, EPA is then required to assess what level is feasible with available technology. Ultimately, an enforceable standard, the maximum contaminant level or "MCL" is set based on the level that is feasible utilizing BAT, or "best available technology". When developing the BAT, EPA is required to take into consideration field conditions and cost. Consideration is also given to what levels are present and whether analytical techniques are available that are consistently defensible (vinyl chloride is an excellent example of an MCL set based on available analytical tools). When analyzing the benefits, the factual basis of whether the benefits are likely to occur as a result of such treatment must be examined. In light of the SDWA criteria, and the status of 1,4-dioxane on the standard setting agenda of the EPA (it presently is not being considered), we are required to apply the SDWA criteria when evaluating a site-specific standard for this site.

Conclusions

Based on information gathered to date, including bench-scale treatment testing and a treatment system vendor and operator survey, ARCADIS concludes that treatment of 1,4-dioxane to low levels such as the 3 or 6 micrograms per liter (μg/L) proposed by the USEPA and PADEP for the Bally PWS is **not feasible,** applying the EPA standard for establishing MCLs under the SDWA. Given the byproduct formation, lack of performance history at similar sites, and reliance upon lab to field extrapolation, what likely will constitute BAT for 1,4-dioxane would not be able to achieve the low levels proposed by the regulatory agencies and would most likely result in additional health concerns (the latter as a result of the byproduct formation). In short, the only feasible option that will allow treatment for 1,4-dioxane in the Bally PWS is an appropriately selected cleanup standard that reflects both the generic treatment limitations as well as the site-specific concerns.

If you have any questions regarding this evaluation, please contact us at (267) 685-1800.

Sincerely,

ARCADIS G&M, Inc.

Michael F. Bedard, P.E.
Project Manager

Frank Lenzo, P.E.
Project Director/Associate

for

Dr. Fred Payne
Project Advisor/Vice President

Attachment

Copies
Ron Gahagan

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Summary of Bench-Scale Testing Analyses
Bally Municipal Well No. 3 Water

Table 1. Concentration of 1,4-Dioxane Versus Irradiance Time for UV/Peroxide Bench-Scale Testing

	1,4-Dioxane Concentration (μg/L)		
Time (min)	Test # 1 (7.3 mg/L Peroxide)	Test # 2 (3.5 mg/L Peroxide)	Test #3 (6.7 mg/L Peroxide)
0	288.8	254.1	295.7
30	260.1	232.9	218.6
30	220.6	225.5	300.7
60	131.3	205.9	162.5
60	125.1	210.8	147.6
90	58.4	161.7	113.3
90	70.1	169.6	103.4
120	32.5	162.3	75
120	26.4	140	63.9

Table 2. Concentration of 1,4-Dioxane Versus Ozonation Time for Ozonation Bench-Scale Testing

	1,4-Dioxane Concentration (μg/L)	
Time (min)	Experiment Set #1	Experiment Set #2
0	60	58
7.5	10	4
15	< 1	< 1
30	< 1	< 1

Table 3. Byproducts Testing Results, UV/Peroxide Bench-Scale Testing (10 mg/L peroxide)

Time (minutes)	1,4-Dioxane (μg/L)	Bromate (μg/L)	Formaldehyde (μg/L)
0	53	NA	NA
7.5	15	< 5	42

NA: Not Analyzed

Table 4. Byproducts Testing Results. Ozonation Bench-Scale Testing

Time (minutes)	1,4-Dioxane (μg/L)	Bromide (μg/L)	Bromate (μg/L)	Formaldehyde (μg/L)
0	58	40	< 5	5
7.5	4	< 10	62	9
15	< 1	< 10	59	13
30	<1	< 10	58	8.4

Note: Water for all testing was collected from a tap after the second air stripping tower but prior to the water chlorination system.